الامتحان الوطني الموحد للبكالوريا
المسالك الدولية- خيار إنجليزية
الدورة الاستدراكية 2017
- الموضوع -

RS 28E

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
المركز الوطني للتقويم والامتحانات والتوجيه

المادة	الفيزياء والكيمياء	مدة الإنجاز	3
الشعبة أو المسلك	مسلك العلوم الفيزيائية – خيار إنجليزية	المعامل	7

The use of non-programmable scientific calculator is allowed

This exam paper consists of four exercises

Exercise I (7 points):
- Silver-electroplating by electrolysis.
- Esterification reaction.

Exercise II (3 points):
- Diffraction of light wave.
- Cobalt-60 nucleus.

Exercise III (4,5 points):
- Response of the RC dipole to a step voltage.
- Study of the RLC circuit in the negligible damping case.

Exercise IV (5,5 points):
- Study of the motion of an exoplanet around its star.
- Energetic study of a mechanical pendulum.

EXERCISE I (7 points)

Marking scale

Part one and part two are independent

Part one: Silver-electroplating by electrolysis

Electrolysis has many industrial uses; for example electroplating some metals with a thin layer of another metal to protect it against the corrosion or to brighten it.

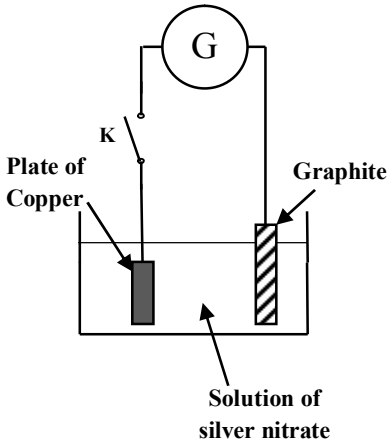
This part of the exercise aims at studying of electrolysis the silver-electroplating process of a plate of copper.

Given:

-Redox pairs involved are $Ag^{+}_{(aq)} / Ag_{(s)}$ and $O_{2(g)} / H_2O_{(\ell)}$;

- $1F = 96500\,C.mol^{-1}$;

- Molar mass of silver: $M(Ag) = 108\,g.mol^{-1}$.



We immerse completely a plate of copper into the aqueous solution of the silver nitrate $Ag^{+}_{(aq)} + NO^{-}_{3(aq)}$, then we connect it with a conductor wire to one pole of a power supply G, the other pole of G is connected to the electrode of graphite as shown in the diagram on the right.

When we switch on K, the power supply G provides the circuit during a period of time $\Delta t = 70\,min$ of an electric current of $I = 0,4\,A$. The dioxygen is produced at the graphite electrode and the silver is uniformly deposited on the plate of copper.

We consider that the nitrate ions do not react in this electrolysis.

Choose the right statement from the given list and copy it on your answer sheet next the corresponding number of the question. (No justification or explanation is needed).

0,5 **1-** During the silver-electroplating process by electrolysis:

■ The plate of copper represents the anode and it is connected to the negative pole of the power supply G.

■ The plate of copper represents the anode and it is connected to the positive pole of the power supply G.

■ The plate of copper represents the cathode and it is connected to the negative pole of the power supply G.

■ The plate of copper represents the cathode and it is connected to the positive pole of the power supply G.

0,5 **2-** The chemical equation occurring at the graphite electrode is:

■ $Ag^{+}_{(aq)} + e^{-} \rightleftarrows Ag_{(s)}$

■ $2O^{2-}_{(aq)} \rightleftarrows O_{2(g)} + 4e^{-}$

■ $6H_2O_{(\ell)} \rightleftarrows O_{2(g)} + 4H_3O^{+}_{(aq)} + 4e^{-}$

■ $Cu_{(s)} \rightleftarrows Cu^{2+}_{(aq)} + 2e^{-}$

0,75 **3-** The mass of silver m(Ag) deposited on the plate of copper during the period Δt is:

■ $m(Ag) \simeq 30\,mg$

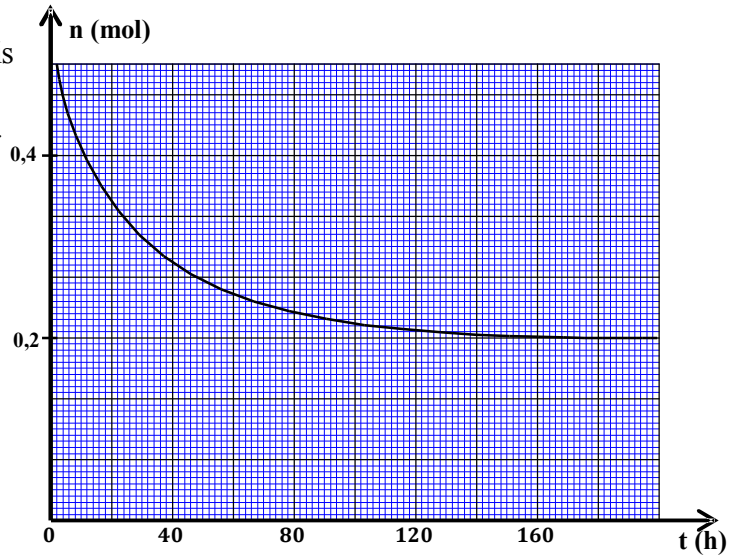
■ $m(Ag) \simeq 1,9\,g$

■ $m(Ag) \simeq 0,5\,g$

■ $m(Ag) \simeq 1,9\,mg$

Part two: Esterification reaction

To manufacture the ethyl ethanoate, a lab assistant prepared a number of graduated tubes. In each one, he mixed the volume $V = 34,5\,mL$ of pure ethanol with $0,6\,mol$ of ethanoic acid. Hermetically, he put them into a water-bath of a constant temperature of 100°C.To monitor the time-evolution of the chemical system, the lab assistant took out at an instant t of time a tube from the water-bath and immersed it in iced water. He titrated the amount of acid remaining in this tube at this instant using a solution of the sodium hydroxide of a known molar concentration. The curve below shows the variation of ethanoic acid amount of substance **n** remaining with time during the reaction.

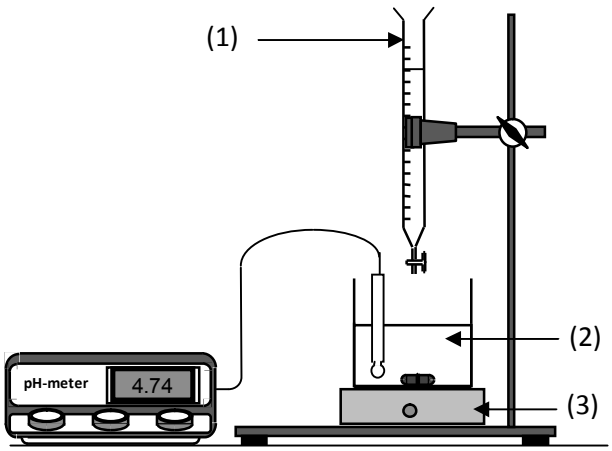


Given:

- The molar mass of ethanol: $M(C_2H_5OH) = 46\,g.mol^{-1}$;
- Density (mass per unit volume) of ethanol : $\rho = 0,8\,g.cm^{-3}$.

0,25 **1-** What is the purpose of using iced water before making titration?

0,75 **2-** The diagram below represents the experimental set-up of an acid-base titration. Give the name of each part which is referred by number.



0,5 **3-** Show that, at the initial state, the reactants have the same amount of substance (equimolar mixture) in each tube.

0,5 **4-** Write by using structural formulae, the equation of the reaction occurring in each tube.

1 **5-** Determine the composition of the reaction mixture in each tube at the equilibrium state.

0,5 **6-** Show that the value of the equilibrium constant is $K = 4$.

1 **7-** The lab assistant repeated the same experiment at the same temperature by using $0,4\,mol$ of pure ethanol and $0,1\,mol$ of ethanoic acid in each tube.

Determine the yield of the reaction in this case.

0,75 **8-** To obtain 100% as a yield of the ethyl ethanoate manufacturing, the lab assistant substituted the ethanoic acid by its anhydride.

Write by using the structural formulae, the equation of the reaction which occurs.

EXERCISE II (3 points)

Part one and part two are independent

Part one: Diffraction of light wave

A diffraction experiment is set up on a narrow wire of diameter $d = 0,1\,mm$ and a monochromatic light source wavelength λ.

A diffraction pattern appears on a screen at distance $D = 3,5\,m$ from the wire. The width of the central spot is $L = 56\,mm$.

Assume that the angular separation θ is too small to take $\tan(\theta) \approx \theta$.

1 **1.** Calculate the wave length λ of the light source used in this experiment.

0,5 **2.** We change the previous light source with another violet.

How does the width of central spot change? Justify your answer.

Part two: Cobalt-60 nucleus

The disintegration of the $^{60}_{27}Co$ nucleus produces the nucleus of the nickel $^{60}_{28}Ni$ and a particle X.

Given:

- Mass of the nucleus $^{60}_{27}Co$: 59,91901 u ;
- Mass of the nucleus $^{60}_{28}Ni$: 59,91543 u ;
- Mass of electron: 0,00055 u ;
- Mass of proton: : 1,00728 u ;
- Mass of neutron : 1,00866 u ;
- The binding energy per nucleon of the nucleus $^{56}_{28}Ni$ is 8,64 MeV/nucleon;
- $1u = 931,5\ MeV.c^{-2}$.

0,5 **1.** Identify particle X, then determine the type of the radioactivity of the $^{60}_{27}Co$ nucleus.

0,5 **2.** Calculate, in MeV, the energy released $\mathscr{E}_{pro}$ (produced) during this disintegration.

0,5 **3.** Determine, in Mev/nucleon, the binding energy per nucleon $\mathscr{E}$ of the $^{60}_{28}Ni$ nucleus. Deduce which one of the nuclei $^{60}_{28}Ni$ and $^{56}_{28}Ni$ is the most stable.

EXERCISE III (4,5 points)

A teacher of physics wants to study, in first step, the impact of the resistance of a resistor on the time-constant while charging a capacitor; and in a second step, to study discharging this capacitor through an inductor (coil).

To achieve his goal, the teacher asks his students to make the set-up sketched in figure1, which is made up of:

-An ideal power supply, its electromotive force is E= 6 V;

-A variable resistor; its resistance is R;

-A capacitor, its capacitance is C;

-An inductor (coil), its inductance is L (its resistance is negligible);

-A double switch K .

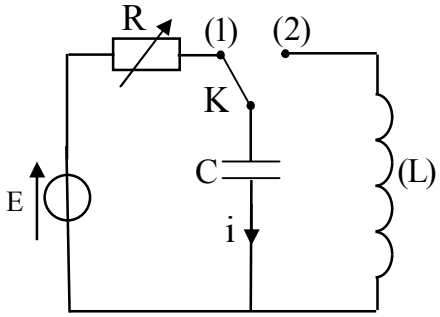


Figure 1

1- Response of the RC dipole to a step voltage

A student puts the switch K on position (1) at an instant assumed origin of time (t=0).

The curve (C_1) in figure 2 shows the variation with time of the voltage between terminals of the capacitor $u_C(t)$ when the resistance of the resistor take the value R_1=20Ω. And the curve (C_2) shows the variation of the same voltage $u_C(t)$ when the resistance of the resistor is R_2.

T_1 and T_2 are the tangents of curves (C_1) and (C_2) at t=0.

0,25 **1.1-** Copy figure1 on your answer sheet and show on it how to connect the datalogger to monitor the voltage $u_C(t)$.

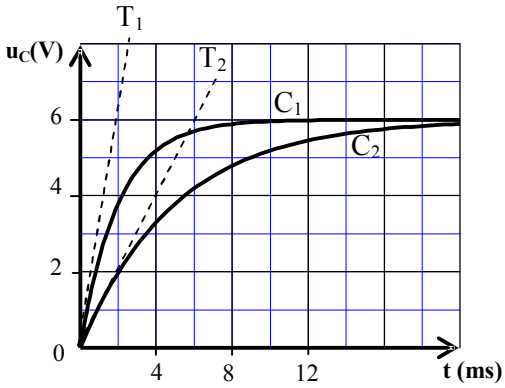


Figure 2

0,5 **1.2-** Find out the differential equation of the voltage $u_C(t)$.

0,5 **1.3-** The solution of this differential equation is $u_C(t) = A(1 - e^{-\frac{t}{\tau}})$.

Determine both the expression of the constants A and τ in terms of the circuit's parameters.

0,5 **1.4-** By investigating the two curves of figure2, determine the values of C and R_2.

0,5 **1.5-** What would you deduce about the impact of the resistance of the resistor on the time-constant?

2- Study of the RLC circuit in the negligible damping case

When the capacitor ($C = 100\,\mu F$) is completely charged, a student puts the switch K on position (2), (see the figure1).

The curve in figure 3 represents the variation of the charge q(t) of the capacitor with time.

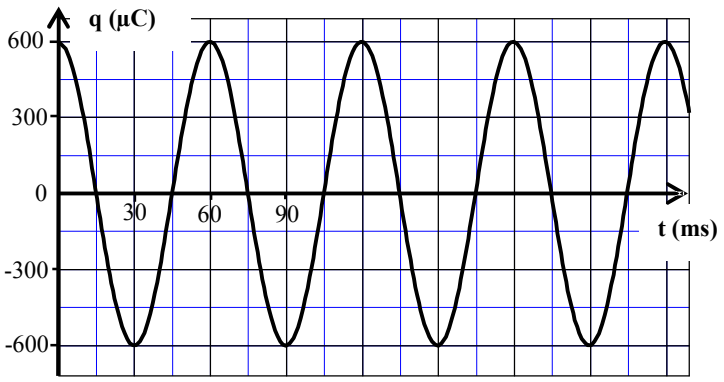


Figure 3

0,5 **2.1-** Find out the differential equation of the charge q(t) of the capacitor.

0,5 **2.2-** The solution of this differential equation is $q(t) = Q_m \cos(\frac{2\pi t}{T_0})$.

Find out the expression of the natural period T_0 in terms of L and C.

0,5 **2.3-** Verify that the value of the inductance L of the inductor studied is $L \approx 0,91H$.

0,75 **2.4-** Calculate the total energy of the circuit at instants $t_1 = 0$ and $t_2 = \frac{T_0}{4}$. Justify this result.

EXERCISE IV (5,5 points)

Part one and part two are independent

Part one: Study of the motion of an exoplanet around its star

An "Exoplanet" is a planet orbits a star other than the Sun. In the last few years, astronomers have discovered thousands of exoplanets by using sophisticated tools and techniques.
"Mu ara" is a star, its symbol S, located at approximately 50 light years far from our solar system. Four exoplanets orbit round "Mu ara".
This exercise aims at determining the mass of "Mu ara" using the Newton second law and the Kepler laws on one of these exoplanets, its symbol is b.
The star S is a uniform spherical mass. The exoplanet b follows a circular path and its dimensions are negligible.
There is only the universal gravitation force acting on the Exoplanet b by the star S.
We study the motion of b in a frame of reference linked to the centre of the star assumed Galilean.

Given:

- Gravitational constant: $G = 6,67.10^{-11}\,(\text{S.I units})$;
- The radius of the trajectory of b around the star S is $r_b = 2,24.10^{11}\,\text{m}$;
- The period of the trajectory of b around the star S is $T_b = 5,56.10^{7}\,\text{s}$;

0,5 **1-** Write the expression of the magnitude $F_{S/b}$ of the universal attraction force exerted by the star S of the mass M_S on the exoplanet b of mass m_b.

2- By applying the Newton second law :

0,75 **2.1-** Show that the circular motion of the exoplanet b is uniform around the star S.

0,75 **2.2-** Establish the Kepler third law: $\frac{T^2}{r^3} = K$ where K is a constant.

0,5 **2.3-** Determine the value of the mass M_S of the star S.

Part two: Energetic study of a mechanical pendulum

An oscillating system (S) consists of a solid (S) of centre of inertia G and of mass m fixed on the one end of a horizontal spring with non-contiguous turns of spring constant $K = 20\,N.m^{-1}$ and its mass is negligible. The other end is attached to a fixed stand. (figure 1)
We pull the solid (S) by a distance X_m then we release it without initial velocity. The solid oscillates on a horizontal plane without friction.
We study the motion of the centre of inertia G in a frame of reference $(O,\vec{i})$ linked to the earth. This frame is Galilean.
At equilibrium, the position of G coincides with O the origin of the frame.

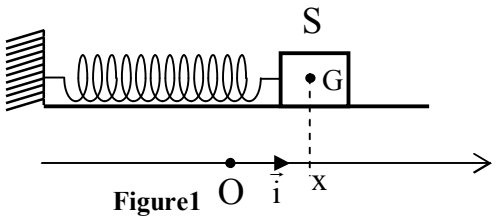


Figure1

We locate the position of G at one instant of time t using the displacement x in the frame $(O,\vec{i})$.
We assume the gravitational potential energy to be zero on the horizontal plane passes by G and the elastic potential energy to be zero when the centre of inertia G at the position of equilibrium (x=0).
The equation of the displacement-time of G is written as $x(t) = X_m.\cos(\frac{2\pi t}{T_0} + \varphi)$.

The curve in figure 2 represents the displacement-time $x(t)$.

0,75 **1-** Determine the values of X_m , T_0 and φ .

0,75 **2-** Determine the value of the mechanical energy E_m of the oscillating system studied.

0,75 **3-** Find out the value of the kinetic energy E_{K1} at the instant $t_1 = 0,3s$.

0,75 **4-** Calculate the work $W_{AB}(\vec{F})$ of the restoring force applied by the spring on the solid (S) when its centre of inertia G displaces from position A ($x_A = 0$) to position B ($x_B = \frac{X_m}{2}$).

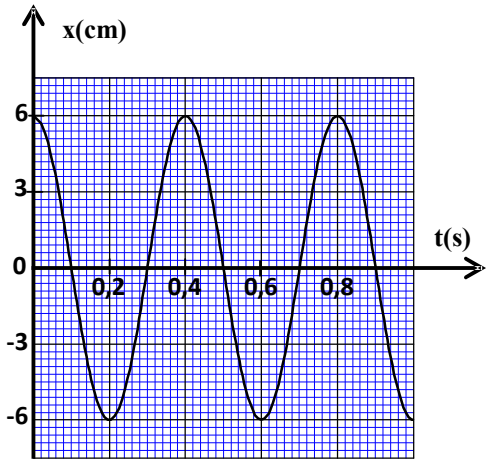


Figure2